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AUTHOR de Diana, I. P. F.
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ABSTRACT

This paper discusses the requirements for implementation of computer-based learning (CBL) and presents three examples of activities related to CBL in the Netherlands in 1979-80. Problems in developing a technology for CBL materials production are discussed, and several insights behind the development of such a technology are considered: (1) it is useful to make a distinction between the developmental systems for CBL materials and the delivery systems; (2) there is a growing tendency to use general purpose high programming languages as well as computer-assisted instruction (CAI) design languages for the development of CBL; (3) CAI is increasingly perceived to be more than an automated version of programmed instruction; (4) an emphasis on formalizing procedures for programming design and development has been emerging; and (5) work on computer-based simulation has made an important contribution to the growth of CBL technology. The problems of credibility and limited resources in creating favorable conditions for the implementation of CBL are considered, along with potential means of addressing these problems in Western Europe. Seven references (five in Dutch and two in English) are listed. (MES)

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A FUTURE FOR COMPUTER BASED LEARNING ?

I.P.F. de Diana

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A FUTURE FOR COMPUTER BASED LEARNING ?

I.P.F. de Diana

A colloquium held for the UCLA Graduate School of Education, Los Angeles, August 20, 1980.

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Excerpt

Implementation of Computer Based Learning materials is described as the third step in a sequence. The other steps being the development of a technical foundation for Computer Based Learning and the development of a technology for developing Computer Based Learning materials.

It is argued that all these steps have to be taken succesfully in order for Computer Based Learning to become established in the institutionalized educational systems of the technological highly developed countries.

Some problems and solutions pertaining to the development of a technology for Computer Based Learning materials and implementation of these materials are discussed.

Descriptions

Computer Based Learning, CAI, Implementation of instructional materials, learning materials development.

INTRODUCTION

It is not my intention to sketch a scenario for you of the future role of Computer Based Learning (CBL) in education. Nor to speculate about the different forms of CBL that might be developed in the future. Neither to explicate why CBL is so useful or wanted. Rather, I will try to give some indications of what will be needed in order for CBL, as we know it today, to become implemented in our education on a rather extensive scale. In that I will give you some examples from western european situations that typify some implementation aspects as well as problems.

Implementation, in regard to CBL, is in my opinion the third step in a sequence. The first step consists of the development of a sufficient technical foundation, e.g. the development of adequate hard- and software tools. The second step, consists of the development of a technology for the development of CBL materials, according to specific goals and specifications. Only if these steps are taken to a sufficient degree, will it be possible to actualize the large scale implementation.

AS it is nowadays, even though the technical foundation is rather well developed, the technology for the production of CBL materials and implementation problems are being worked on at the same time.

As it will probably take some years to develop the production technology, and keeping this step sequence in mind, you might wonder whether the implementation problems can be solved in the meantime. However, even though they may not be completely solvable, attempts to do so will give valuable information at the time when real large scale implementation programs will be undertaken.

Even though CBL can take on different forms, such as Computer Assisted Instruction, Computer Managed Instruction, Computer Based Simulation, Interactive Theorem Proving, Interactive Data Analysis and Retrieval etc, it is not my intention to differentiate here too much between these forms. All the forms that CBL may take (and might take) can be typified as being a teaching-learning form of an interactive nature, between man and machine in which a programmed computer is used as a data gathering and data delivery system for an explicit educational goal.

Or course the CBL activity can be more or less extensive, ranging from the delivery of a complete CAI course or managing a complete school curriculum to delivering part of a lesson in which a Computer Based Simulation is used to elucidate a physics proof.

So not giving too much attention to the various forms of CBL, or to the differences in extent of use, I would like to recapitulate the title of my colloquium: "A future for CBL?" and explicate it in this way: "Can CBL be given an institutionalized place in Western European educational systems?"

Given that I am convinced that this question is not basically a technical one, for me the question pertains to the development of an adequate CBL material development technology and the solving of implementation problems.

Before further analyzing these aspects of the question, I would like to present some examples of activities going on in the Netherlands pertaining to introducing CBL or developing CBL materials.

The three examples I will give you, all took place in the last month of 1979 and the first three months of 1980. So you might say CBL is very much in the public eye in the Netherlands.

Examples from the Netherlands

1. Since fall 1977, the University of Amsterdam, has invested several million dollars in a so called "Plato Pilot Project" (Plato proefproject). For this amount, some seven Plato CDC terminals were hired, likewise some student encoders and some temporary faculty. The goal of the project was to produce courseware for several Departments of the University and to investigate the value of one particular version of CBL, viz. the CDC Plato system for large scale University use (1).
   The involved Departments in the project included the Music, Physics, Sociology and French Departments. Several CAI courses were produced in a period of two years, such as a pitch discrimination course, a statistics course for learning SPSS and a course for learning irregular French courses.
   These produced courses functioned as replacements for already existing forms of these courses. Most of the students that had to take these

courses went trough the Plato versions.
In addition, several already existing courses from the Plato library were tried out for their potential usefulness in the regular university programs, among others in the physics department.

Several of the departments involved were highly enthusiastic at the end of the two year period. The Music and French Departments claimed to have decreased the amount of study time needed for succesfully finishing the courses in, respectively, pitch discrimination and irregular French verbs with approximately half the original time needed.
The faculty involved in these departments, were able to increase their time for research activities in that period concordantly, and were equally enthusiast.

Early in 1980 (March 11, 1980) the University Council of the University of Amsterdam turned down a proposal for a prolongation of the Plato Pilot Project (2). The proposal included an increase of hired terminals and student encoders as well.

Several Departments were furious about the turn things had taken. They insisted that the Pilot Project could be regarded to have been highly successful and feared to have to go back to former teaching methods and to have to increase again the instruction time needed for reaching the program goals.

2. The second example I would like to give you had to do with the preparations that are under way in the Netherlands in order to establish a Dutch Open University. The highly successful British Open University is perceived in several other countries to be an important prototype of an educational facility for people that have missed the direct entrance into a regular University. Likewise in the Netherlands, so plans are there to create a Dutch Open University. A location has been decided upon and several of its subsystems are studied in order to be able to develop them in time.
One of these subsystems is the use of media for instructional purposes. As the Open University will offer forms of distance education, media play a very important role in the reaching of the educational objectives of the Open University.

To report on what media to use and how to use them was the mission of a group of researchers from the "Bureau Onderzoek van Onderwijs" (Office for Research in Education) of the University of Leiden. They received their mission from the Preparatory Commission for the (Dutch) Open University. After some years' work they reported. Their report (3) was the object of an intense discussion at the Dutch Educational Research Days, a yearly Dutch counterpart of the AERA conference.

Summarized, the report stated that besides written materials, the computer had to be regarded as the foremost medium to be used for a future Open University. Classical audiovisual media took a minor position in the report.
Comparing the computer and classical audiovisual media for effectiveness in a distance education setting, it was concluded or stated that:

- classical audiovisual media as yet have not proven to be effective in distance education settings
- classical audiovisual media in general do not have the interactive possibilities that the computer offers
- even the British Open University, though it did not start out making heavily use of the computer, relies more and more and for an increasing number of functions on the computer
- decreasing hardware costs and increasing communication facilities including a specialized data transmission network that the Dutch PTT (Post, Telegraph, Telephone Company) is building, will make it rather easy for future Open University students to work with various forms of CBL.

The report recommended that, by the time the Open University receives its first students (probably in some four years from now):

- the Open University should make use of several forms of CBL (such as CAI and CMI)
- the Open University should offer a part of its programs only in CBL form
- the Open University should make use of production teams for course materials in the way the British Open University does. For CBL courses, computer-specialists should be added to these teams.

3. The governments of several Western European countries are seriously concerned about the impact that microelectronics in the coming decade might have upon various aspects of the society; therefore they have installed studygroups

to explore the possible consequences and to advise on governmental policies to be adopted, in order to ride upon the innovative flow rather than be drowned by it.

In the U.K. and the Netherlands, reports of these groups have been published.

The Dutch studygroup, called the "Commission Rathenau", after its chairman, prof. W. Rathenau, published its report in November 1979 (4). The publication of this report started a large public debate.

No wonder that education as a societal subsystem in the Netherlands that takes some 29% of our governmental yearly gross spending budget is one of the area's of social life that the Commission Rathenau has studied for possible consequences of microelectronic impact.

A heavy emphasis was laid in the report on the necessity for taking an active stand on the microelectronics developments, rather than staying passive.
For education this meant that besides recommendations for a broad use of microelectronics in education, the commission especially recommended new curricular elements in among others methematics and language education, pertaining to the use of computers.

The commission advised the Dutch government to spend the coming years on research and development activities, pertaining to the possibilities and consequences of the applications of microelectronics in the various areas of social life.

Strongly influenced by this report, the Secretary-General of our Department of Education has taken the stand that a fair amount of R&D money need to be provided in the coming years for researching the possibilities of applying microelectronics in education.

PROBLEM LOCALIZATION

As I have said, all these examples I have given you, took place in the last month of 1979 and the first three months of 1980. All these involved a kind of national scale attention to CBL.

The turning down of the proposal for a prolongation of the Plato Pilot Project made it clear to the Dutch Universities that funded CBL materials development projects are vulnerable.

The report from the Open University media study group made it clear that the computer is to be considered as an extremely important tool for the functioning of a Dutch Open University. The Commission Rathenau could start a flow of R&D money from our Department of Education for research on CBL.

In a small country like the Netherlands that has only 14 million inhabitants these developments certainly focussed the public eye on CBL. Yet the picture it received may have been a confused one.

On one side it discovered a strongly supportive policy and planning emphasis on the use of computers in education; on the other side it witnessed the turning down of a large scale CBL materials development project proposal. The project itself was according to some involved university departments a big success.

Clarifying however, is to point out that the main reason for turning down the proposal for a prolongation of the Plato Pilot project was not that the University Council of the University of Amsterdam was not convinced of the possibilities and usefulness of CBL. Rather they thought the Plato system too expensive for large scale University operation. Indications that a microcomputer based approach to CBL would be a lot cheaper without loosing too much quality, played a major role in their decision.

So, the confused picture that might have developed concerning the merits of CBL, is understandable but not fully justified.

It might be said, that the general climate in the Netherlands on the policy and planning level is rather in favour of introducing CBL, yet the actual introduction encounters some severe problems, among others related with the fact that a technology for the production of CBL materials is not yet well developed.

But even if a technology for the development of CBL materials had been developed, planning committees and policy makers would still have to overcome implementation problems in order to create an institutional place for CBL.

The Plato Pilot Project encountered two severe problems: a clash of ideas how to go about producing CBL materials; e.g. whether to use a small systems approach or a large system, and problems connected with an expansion of scale viz. cost factors. Likewise, the Dutch Open University will have to face CBL development problems as well as implementation problems.

Proceeding therefore from these examples, we might ask in order to analyze our problem further:
- what will be needed to develop a technology for the development of CBL materials and
- how can we succeed in implementing CBL in institutionalized educational systems?

A TECHNOLOGY FOR CBL MATERIALS PRODUCTION

A technology for developing CBL materials might be described as: a collection of well validated design, construction and evaluation techniques for CBL materials as well as a scientific body of knowledge concerning why, under that conditions and how to apply them.
Such a technology as yet does not exist. However, the experimenting with CBL and especially CAI that took place in the late '60's and early '70's, especially in the U.S.A. did lay a foundation.

Among other things it made clear what the consequences could be if a large scale development approach would be undertaken, based upon mainframe computer systems.

A fair number of large scale development attempts resulted in overloaded computer systems, if these systems were not of a dedicated kind. The reason for that was the often extreme amount of memory space needed for translating and running CAI programs. This large amount of memory space often resulted from the use of so called CAI (design) languages, special purpose high level programming languages.

These CAI languages seemed to offer the advantage that a framework was offered to the individual CBL developer for preparing courseware. The price that was to be paid was often severe though; not only did these languages often taken excessive memory space for the translation and running of courseware, the framework that they offered to the developer was often solely based on programmed instruction ideas and techniques.

Inadequacy and often the unreliability of the large computer systems used then for the complex translation and compilation procedures needed for these CAI design languages, coupled with a conceptually restricted approach to CBL (based upon programmed instruction), inadequate terminals, and a large confusion about what CAI language to use and how to make the resulting courseware portable, caused a near collapse of interest in CBL R&D in at least the U.S.A. in the early and middle seventies.

This collection of problems, that caused the almost collaps of interest in CBL R&D may be ascribed to problems of several types; mainly
1. technical problems and
2. technological problems.

Several technical problems, such as overloaded computer systems, inadequate terminals and unreliability of the computer systems used, have been almost solved since then.
New generations of colour graphics terminals, cheaper and more abundant memory space and strongly improved systems have appeared since the late '60's.

Technological problems connected with CBL materials development, such as questions pertaining to the use of CAI design languages have not all been solved yet.

However, some trends indicate that the roots of such a technology are developing. At these roots are several insights, of which I only will mention a few.
1. It is useful to make a distinction between the developmental systems for CBL materials and the delivery systems.
   It has been proven that the delivery systems for CBL can be of a much simpler type (e.g. an inexpensive microcomputer) than the system used for development.

Even seemingly a rather trivial distinction, if has nevertheless a tremendous consequence. CBL materials can be developed at large central systems making use of their potential, and be delivered by means of inexpensive local site facilities.

2. There is a growing tendency not only to use CAI design languages for the development of CAI, but general purpose high programming languages as well. Besides often needing large memory space, most CAI design languages are grafted upon programmed instruction techniques and they are therefore highly restrictive in regards to the kinds of materials that can be developed. Furthermore, courseware developed by means of these languages is often not portable.
   Several research institutes have opted for an approach, in which a high level general purpose language like PASCAL, extended with special purpose subroutine libraries is used for the coding of the educational software. Such an approach has for instance been adopted by the Educational Technology Center of the University of California at Irvine (UCI).

   The development of a compiler, by means of which materials that are coded in some CAI design languages, such as PLANIT and TUTOR can be translated into PASCAL is under way at the informatics specialization group of the Delft University of Technology in the Netherlands.

   Developing courseware in PASCAL has two main advantages compared with using CAI design languages:
   1. PASCAL as a general purpose higher programming language is not restrictive like most of the CAI design languages: it allows all possible instruction strategies to be adopted.
   2. As there are in the PASCAL versions of the different computer systems only slight differences, it is easy to adapt existing PASCAL programs (or courseware developed in PASCAL) to another system than the one that was used for development. Therefore, programs that are coded in PASCAL can be said to be fairly portable. The same holds true of course for CBL materials that are developed in PASCAL.

3. CAI, which was conceived in the late '60's as an automated version of programmed instruction, is increasingly perceived to be more than that.

Even though by means of a computer programmed instruction can be automated, this does not mean that all computer based instruction has to adopt a programmed instruction approach. CAI actually shared a part of the strongly waned interest in programmed instruction because it was perceived to be an automated version.

In fact, CAI can take on as many different forms as there are conceivable instructional strategies: the reason for that is simple, the strategies are programmable too.

So approaches that have been undertaken the last years, to approach CAI from, for instance, a mathematical learning theory point of view or from a more classical content-based curriculum development point of view do give a lot of new insights in CAI problems and possibilities.

4. An emphasis has been developing to formalize procedures in use for program design and development (e.g. courseware design and development). This development runs parallel with the progress that has been made in the field of software engineering.
   Software engineering originated as a reaction caused by the "software crisis" in the middle '60's. At that time it was unclear what sets of rules to apply in order to develop a well structured program in accordance with prespecified criteria.
   This lack of knowledge may be described as the starting point for the development of a collection of methodologies for the design and development of prespecified and well structured programs.

   CBL materials developers can make use of these methodologies in order to develop CBL materials more easily and more accurately.
   In the Educational Technology Center (UCI), developments like these are under way, in an attempt to formalize the CBL materials development proces by means of a specific software design methodology, SADT.

5. An important contribution to the growth of a CBL technology is made by the work on Computer Based Simulation (CBS) thas has been done. CBS is a strongly growing field. The technology for the development of a computer based simulation is rather well understood, as can be witnessed by the number of books published on this topic. CBS is becoming a very popular teaching method with mathematics, physics, science and biology

teachers, especially in the U.K. and Canada.
CBS has become so popular probably because it can offer among other:
- to visualize experiences that otherwise cannot be made visual
- learning experiences otherwise to costly or dangerous to present to the pupils.

A stimulating condition for the growth of a CBL technology is the fact that in some countries, supported by the Government, there are active programs to stimulate the development and use of CBL materials.
Very well known and to my idea exemplary, is the National Development Programm for CBL, that ran for five years, from 1973-1977 in the U.K.
The programm was supervised by the Council for Educational Technology, a kind of National Steering Committee for CBL.
Lots of schools, colleges and Universities started with the production of CBL materials. In fact the program was so successful that there exists in the U.K. nowadays some very active and innovative groups that work in a number of fields of academic science.

In March 1980, the U.K. Government announced a follow-up program, the "Microelectronics development programm for Schools and Colleges". As Mr. Neil MacFarlane, parliamentary under secretary of State at the Department of Education and Science said:
"The programm will give schools and colleges a better understanding of the potential applications of microelectronics technology by commissioning new development projects and by building on existing work in this field".

One of the new developments is the construction of a national U.K. data-bank for CBL materials and documents.

The insights I have discussed and the stimulation conditions that prevail in some countries for the development of CBL materials do not result automatically in a technology for the development of CBL materials.
Additional research is needed for that. Research on such topics as:
- how to formalize procedures for the development of CBL materials, in a structured way and in different instructional modes
- how to evaluate CBL materials; not only as finished products, but while they are in the process of being developed too

- how to use computer graphics in CBL in order to optimize learning processes
- what kinds of relationships do there exist between different modes of CBL and instructional target groups (e.g. profile matching problems)?

Given the amount of attention and the prospects for R&D funding for CBL in several Western European countries and assuming that activities in the U.S.A., such as taking place at UCI will continue, the needed technology is likely to be developed in the coming years.

IMPLEMENTATION ASPECTS

In order for CBL to get a place in the institutionalized educational systems in Western Europe, besides an adequate technical base and a fairly developed technology, a process of directed implementation is needed.

Implementatin includes more here than the introduction of a new development. It includes the creation of the conditions under which the development is likely to settle and grow as well as selecting the right introductory approach and the right kinds of developmental seeds.

As for creating the conditions for settlement and growth: Nick Rushby of the CEDAR project, Imperial College of London, makes a distinction between problems of credibility and problems of limited resources in creating favorable conditions for the implementation of CBL (5).

Het states for problems of credibility, that:
" We must accept that it is the teachers themselves who have the experience of teaching their particular subject to their particular students. They are familiar with the difficulties and over the years they have developed approaches which seem to be effective. They can be understandably sceptical of anyone who offers an alternative computer based approach, claiming it to be better because it is individualized, provides deeper or different insights into the subject material or is cheaper. A related problem is that CBL is perceived by many teachers as being beyond their ken, and only for the selected few who are versed in computing and mathematics ...".

A basically good approach to solve these kinds of problems might be the two phase microcomputer implementation program, undertaken by the French government.
Early in the '70's, the French government initiated teacher training courses for some 500 high school teachers, to become fairly acquainted with computer use for educational purposes.
This first phase of the program lasted some four years. The second phase, initiated last year, will also last some four years. It will consist of two kinds of activities:

1. the trained high school teachers will act as teachers themselves in their own schools for other teachers, introducing them to educational microcomputer use
2. the French government will sponsor the large scale implementation of microcomputers in high schools. It is planned to have implemented some 10,000 microcomputers by the middle '80's (6).

This two phase structure clearly solves some credibility problems, as teachers can actually learn from their own colleagues in a trusted setting.

Even more important would it be of course to introduce CBL at teacher training institutions. And even though AV media have become more or less a standard element in Western European teacher training curricula, except for the U.K., computers mostly play a minor role.

The second class of condition problems that Nick Rushby describes are problems connected with limited resources. This is a serious group of problems. The resources often are not only limited in a sense that it is hard to buy hardware and system software, they are very often limited because teachers' time is limited. So the often extremely time consuming production of CBL materials can be seen as a strain on limited resources.

Even though the limited resources for hardware and systems software is a serious implementation problem, it is less fatal to the implementation of CBL than it used to be and will even be less so in near future. Not only have costs of computer hardware been going down for years, they will go on doing so, according to all prognoses from hardware specialists. And not only are the costs going down, the micro's are going up in amount of memory space, ease of use and range of possibilities.
As more and more governments discover the importance of CBL, increased funding to buy hardware is to be expected.

A more serious problem is the cost of producing software. Basically there are two solutions:

- centralized production of educational software for large scale use, either government directed and funded or privately financed
- production of specialized software by groups of teachers in area specialization groups.

Some indications that centralized production might be feasible in near future come among others from a growing interest of commercial publishers in the U.S.A. to start publishing educational software. A kind of textbook market like situation might result from this for CBL packages.

In several Western European countries like The Netherlands and West-Germany state involvement in the central production of CBL might be expected. In the Netherlands we have the Foundation for the Development of Curricula (SLO) that is a central advisory and development institute for all non-university curricula. A strong involvement of this institute with the central production of CBL packages might be expected if our government will support CBL materials production.

Production of software in cooperating teacher groups in specific areas is known from the U.S.A. and the U.K.. These "user groups" seem to flourish. It would be good if governmental spending for groups like these became established. In the U.K. it is by the way one of the aims of the "micro-electronics development programm for Schools and Colleges" to stimulate and support these activities.

CHOOSING THE IMPLEMENTATION APPROACH AND SEED

Implementation is not an activity that can be accomplished overnight. It takes time. So, an implementation approach that slowly grafts new developments to an old and well established stream of activities seems to be attractive.

In Sweden, there are experiments going on in which secondary school curricula in mathematics and physics will make increasing use of hand held calculators and microcomputers. Their use is integrated in the curricular text materials.

Starting with the age group of 12, as I have understood it, they have by now worked up till age group 15-16 years. Becoming an essential and prescribed part of the curriculum, microcomputers are easily integrated in the existing educational situation (7).

Creating conditions and choosing a slow natural approach for implementing is useful and valid, but equally important is it to choose the right kind of seed to sow. Traditionally the seed has been either elements from physics of mathematics education; the reason why is simple. Teachers in these fields are not that shy of computers and often have had experiences with them. The same might be said increasingly so of science and biology education. Probably is it good to keep on capitalizing on this familiarity and to choose elements from mathematics, physics, science and biology curricula as targets for CBL. However, this does not specify the seed very explicitly yet. And that is hard to do anyway. It would probably be wise to give the teachers or teacher groups a say in the choice of elements and then develop and introduce CBL materials for these elements on a large scale in order to create broad testing conditions for CBL materials.

Capitalizing on certain highly attractive characteristics of CBL such as the possibilities to make the invisible visible and creating learning experiences otherwise too costly or dangerous, it is likely that curricular elements which are hard to visualized or costly to demonstrate will become targets.

It would be a pity however if CBL became restricted only the the exact sciences. Music and language instruction for instance do lend themselves very well to CBL, as the first example from the Netherlands has shown. Therefore, preferably, large scale implementation projects should not only include exact sciences, but other fields such as languages and arts as well.

CONCLUSIONS

The developments I have described to you, and given examples of, do not take place all in one country. The field of CBL knows a global spread in its development. Yet if taken together it is possible to trace some conditions that favor the implementation of CBL in institutionalized educational systems.

I have not touched upon the merits of CBL, which is likely to be discussed for years from now on or upon the question whether or not CBL could drive teachers out of their profession. The first I take for granted, the second I do not believe, for as little as textbooks have replaced

teachers will CBL be able to do so.

That there are some serious problems to overcome before this valuable educational development can be of full use I hope to have made a little more clear to you. The question I have chosen as the title of my colloquium is of course not answerable, as it pertains to the future. Yet, I think the structure needed to answer it in the positive can be established in some more years.

Information resources

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